REVIEW ARTICLE

The impact of climate change on the quantity and quality of groundwater

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ABSTRACT

Groundwater resources and their long-term replenishment are controlled by long term climate conditions. Climate change will therefore have a great impact on groundwater resources. Groundwater has to be used and managed in a sustainable way in order to maintain its buffer and contingency supply capabilities as well as adequate water quality for human consumption, also under predicted climate changes. Land use planning has to consider groundwater resources as a precious and finite resource, and take all possible measures to protect groundwater resources and their recharge mechanisms in the long run. The weight of current evidence suggests that climate change is occurring and will continue to occur in the foreseeable future. The rate and intensity of change is not immediately known; however the impacts can already be observed in changes to the quality of drinking water utility source waters. Climate change models, in general, predict an overall warming of the earth. The warmer temperatures associated with climate change are predicted to decrease dissolved oxygen levels, increase contaminant load to water bodies, reduce stream and river flows, foster algal blooms, and increase the likelihood of saltwater intrusion near coastal regions. Climate change impacts to water quality are occurring over a very dynamic range. All of this climate change impacts a role on water quality and have implications for water, wastewater, and storm water utilities. The need is pressing for utilities to address changing water qualities, and this will require fundamental changes in utility operations.

This paper gives information concerning the impacts of climate change on water resources, and particularly groundwater. It provides an overview of the current insights and knowledge on possible impacts and associated technical and management challenges due to climate change.

Keywords: Climate change; Ground water; Management; Consumption

INTRODUCTION

Change in temperature, precipitation patterns and snowmelt can have impacts on water availability. Temperature is predicted to rise in most areas, but is generally expected to increase more in inland areas and higher latitudes. Higher temperatures will increase loss of water through evaporation. The net impact on water supplies will depend on changes in precipitation (including changes in the total amount, form, and seasonal timing of precipitation). Generally speaking, in areas where precipitation increases sufficiently, net water supplies may not be affected or they may even increase. In other areas where precipitation remains the same or decreases, net water supplies would decrease. Where water supplies decrease, there is also likely to be an increase in demand, which could be particularly significant for agriculture (the largest consumer of water) and also for municipal, industrial and other uses [1].

Increases in temperature can affect the amount and duration of snow cover which, in turn can be affect timing of stream flow. Glaciers are expected to continue retreating and many small glaciers may disappear entirely. Peak stream flow may move from late spring to early spring/late winter in those areas where snow pack is important in determining water availability. Changes in stream flow have important implications for water and flood management, irrigation and planning. If supplies are reduced, off stream users of water such as irrigated agriculture in stream users such as hydropower, fisheries, recreation and navigation, could be most directly affected. According to the ministry of water resources, the amount of water available per person in India decreased steadily from 3,450 cm in 1951 to 1,250 cm in 1999, and is expected to decline further to 760 cm per person in 2050. The core of this hydrological study is to assess the influence of future climate change and land use change on the water balance of the LRRB which is yet to be. Climate change is responsible for alterations in amount and the allocation of precipitation and regional temperature thereby having direct impacts on catchment runoff. All regions of the world show an overall negative impact of climate change on water resources and fresh water ecosystems. Areas in which runoff is projected to decline are likely to face a reduction in the value of services provided by water resources. The beneficial impacts of increased annual runoff in other areas are likely to be tempered to in some areas by negative effects of increased precipitation variability and seasonal runoff shifts on water supply, water quality and flood risks [2].

The average global surface temperature is projected to increase by 1.4-3 from 1990 to 2100 for low emission scenarios and 2.5-5.8 OC for higher emission scenarios of green-houses gases (under the new SRES Makers scenarios) in the atmosphere. Over the same period associated rise in global mean sea level is projected between 9 and 88 cm^2 [3].

LITERATURE REVIEW

Groundwater

On a global scale, one third of the population depends on the groundwater for their drinking water, in burn as well as rural areas. Groundwater also plays a pivotal role in agriculture and an increasing portion of groundwater extracted is used for irrigated agriculture. It is esteemed that at least 40% of the world's food is produced by groundwater irrigated farming, both in low income as well as high income countries. In arid and semi-arid areas, the dependency on the groundwater for water supply is between 60 and 100%. Therefore the aim of halving the n umber people without sustainable access to safe drinking water and basic sanitation depends very much on how groundwater resources are developed and managed. However, the importance of groundwater has been marginalized and often neglected in many development strategies and projects. In general support for groundwater management has not received much attention. Only few activities in groundwater management have been supported and this marginally [4].

In many regions and for billions of people in Asia, groundwater is an irreplaceable resource for livelihoods and agriculture. Adverse impacts of

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climate change on groundwater resources are expected, including changes in recharge rates, saline intrusion in coastal aquifers, and decreased long term groundwater storage. However, groundwater is expected to be relatively unaffected by the climate change due its buffering capacity. Groundwater therefore may increase in importance and help to ameliorate the worst effects of climate change on water resources and sustainable development. However, once seriously damaged, recovering groundwater resources requires vast amounts of funds and time [5].

Despite the critical importance of groundwater resources in many parts of the world, there have been very few direct studies of the effects of global warming on groundwater recharge. Although effects on groundwater resources are adequately understood at present. They cannot be ignored. Groundwater is the major source of water across much of the world, particularly in rural areas in arid and semi-arid regions, but there has been very little research on the potential effects of climate change. there is a need to improve understanding and modelling of climate changes related to the hydrological cycle at scales relevant to decision making information about the water related impacts of climate change is inadequate especially with respect to water quality, aquatic ecosystems and groundwater including their socioeconomic dimensions [6].

Possible impacts

The hydrologic (water) cycle a fundamental component of climate, is likely to be altered in important ways by climate change. Precipitation is very likely to continue to increase on average, especially in middle and high latitudes, with much of increase coming in the form of heavy down pours. Changes in the amount timing and distribution of rain, snowfall, and runoff are very probable, leading to change in water availability as well as in competition for water resources. Changes are also likely in the timing, intensity, and duration of both floods and droughts with related changes in water quality. Groundwater supplies or less susceptible than surface water to short time climate variability; they are more affected by long term trends. Groundwater serves as base flow for many streams and rivers. In many areas, groundwater levels are very likely to fall, thus reducing seasonal stream flows. Surface water temperature fluctuates more rapidly with reduced volumes of water, likely affecting vital habitats. Small streams that are heavily influenced by groundwater are more likely to have reduced stream flows and change in seasonality of flows, likely damaging existing wetland habitats. Pumping groundwater at faster rate than it can be recharge is a major concern, especially in parts of the country that have no other supplies. In the plains, for example, model projections indicate that increased drought conditions are likely, and groundwater levels are already dropping. The quality of groundwater is being diminished by a variety of factors including chemical contamination. Saltwater intrusion is another key groundwater quality concern, particularly in coastal areas where changes in fresh water flows and increases in sea levels will both occur. As groundwater pumping increases to serve municipal demand along the coast and less recharge occurs, coastal groundwater aquifers are increasingly affected by sea water. Because of the groundwater a resource has been compromised by many factors, managers are looking increasingly to surface water supplies which are more sensitive to climate change and variability [7].

DISCUSSION

Groundwater, therefore, may increase in importance and help to ameliorate the worst effects of climate change on water resources and sustainable development. Stresses on groundwater have been increasing in India due to population growth and economic development, and groundwater already faces critical implementation challenges. Climate change will add grater pressure on the resources jeopardize sustainability, and intensify inter-state and intra-state conflicts over water, if appropriate adaptation strategies are not implemented. Structural adaptation measures (such as promoting water harvesting and conservation technologies) and institutional adaption strategies (such as promoting local groundwater management) should be incorporated into comprehensive water management plans. The impact of climate change on groundwater resources and adaption opportunities provide a new agenda for water management [8-10].

Due to climate change higher variability in precipitation is very likely to occur along with more frequent extreme events, like storms, floods and droughts. Groundwater will be affected much slower. Increased variability in rainfall may decrease groundwater recharge in humid areas because more frequent heavy rain will result in the infiltration capacity of the soil being exceeded, thereby increasing surface runoff. In semi-arid and arid areas, however, increased rainfall variability may increase groundwater recharge, because only high-intensity rainfalls are able to infiltrate fast enough before evaporating, and alluvial aquifers are recharged mainly by inundations during floods [11-13].

To fill the knowledge gaps and reduced uncertainty regarding the predictions and impacts of climate change on groundwater resources and future groundwater management options, more research is needed. Priority research topics include downscaling studies of global climate change models and assessment of current groundwater management structures and institutions.

Strategies to use and develop groundwater resources under climate change

Although additional research on the topic is needed, climate variability and change can be integral to successful management of groundwater resources. Thus, there is a need to evaluate and understand climate variability and change over the long-term to better plan and manage groundwater resources well into the future, while taking into consideration the increasing stresses on groundwater resources form population growth and industrial, agricultural, and ecological needs. The following are the some of the important strategies to use and develop groundwater resources under climate change.

- Existing water management institutions, policies and water infrastructures in India have not been successful in coping with current groundwater problems, so extra effort will be needed to counter the additional negative effects of climate change.
- Measures to cope with current groundwater stress and potential impacts of climate change include conserving and increasing groundwater storage and diversifying water sources to minimize the risk of water shortages.
- Rainwater harvesting structure for groundwater recharge and for domestic and agricultural use is a feasible structural adaptation option but new policies to promote rainwater harvesting need to be developed.
- Institutional adaption should be promoted, including enhancement of groundwater governance and strengthen local groundwater management. Groundwater management policies can be made more effective by raising local awareness.
- Extensive research at local scales is needed to reduce the knowledge gap regarding the potential impact of climate change on groundwater resources. This information will help to formulate policies to counteract the impacts of climate change.

Measures of adaption and mitigation

The following are the some of the measures to protect the groundwater resources from possible negative effects of climate change.

- The driving force for global warming is the emission of greenhouse gases. Thus, more efforts in mitigating climate change should be undertake to reduce emissions and to develop new technologies.
- A lot of energy to use for groundwater extraction. In this context, large potential lies in the promotion renewable energies, like solar energy which can be used for both groundwater extraction and for distillation of water of inferior quality.
- Wise land use, the protection and maintenance of groundwater systems and technical installations for the simple access to groundwater resources are key to prevent groundwater contamination, ensure sustainability of economic investments and groundwater availability during extreme (flood drought) conditions.
- A very important alternative or supplement to the preservation or restoration of natural infiltration conditions is artificial groundwater

recharge. Artificial groundwater recharge is also described as a kind of (ground) water banking. Protected from evaporation and contamination recharged water can be used for different purposes but first of all drinking water supply.

- Advocated strategies of water saving and use of recycled, treated water becomes even more relevant in times of climatic changes. Instead of relying on precious and finite groundwater for all kinds of water supply, groundwater usage for irrigation purposes should be reduced and submitted with treated municipal wastewater for irrigation. By using good quality groundwater preferably for drinking water, the resource is used in a more sustainable way.
- The amount of water needed for agricultural use is till incredibly high and today is estimated to be 70% of all human extraction. Therefore sound irrigation systems could contribute to avoid the waste of this precious resource. Open canals should be replaced by closed pipes in order to protect against evaporation. To reduce evaporation the soil should be covered completely with plants, and therefore a multilayer storey is suggested. Efficient water use must be the main objective in agriculture and the cultivation of drought resistant plants could be an option.
- Ecosystems must be protected because they serve as water catchment areas and natural infiltration basins. Forests play an important role for the river flora and fauna. Furthermore, erosion is very limited when forest are well developed and dense. These measures or steps can be taken anytime, both to climate change and to reduce general stress on water resources.

CONCLUSION

Groundwater provides a secure, sufficient, and cost-effective water supply, often more reliable than traditional surface water based supplies. However, groundwater, as with surface water is increasingly stressed due to human development, population growth, increased reliance on groundwater and climate change. The strategies such as proper water management policies, development of techniques foe groundwater storage in the climate change are proposed. Adaptation and mitigation of climate change is very essential along with control of global warming gasses into atmosphere.

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